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Research Article

Agronomic Performances of a Rice Somaclone (RSC2018-1) with Potassium Split Applications

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ABSTRACT

RSC2018-1 is a rice somaclonal line derived from the local aromatic rice cultivar '*Benapole*' with a substantially smaller grain size than the mother cultivar. During final field preparation, potassium fertilizer is typically applied in a single dose; however, several scientists have found that split doses of potassium are beneficial for increasing rice grain yield. Thus, the current study aims to assess the impact of potassium split treatments on yield and yield attributes of the rice somaclone RSC2018-1. The experiment was conducted at the experimental Field of Agrotechnology Discipline Khulna University (Southwestern Bangladesh) using a Randomized Complete Block Design (RCBD) with seven treatments and three replications. The treatments were T_1 (K: 41 kg ha^{-1} basal, RDK) (control), T_2 (K: 50% RDK, basal), T_3 (K: 75% RDK basal and 25% RDK 45 DAT), T_4 (K: 50% RDK basal and 50% RDK 45 DAT), T_5 (K: 25% RDK basal and 75% RDK 45 DAT), T_6 (K: 25% RDK basal, 25% RDK 15 DAT and 50% RDK 45 DAT), T_7 (K: 50% RDK basal; 25% RDK 15 DAT and 25% RDK 45 DAT). Various data on growth and yield attributes were recorded and statistically analyzed for ANOVA and the means were compared by Tukey's test with the software Statistix10. The experimental results revealed that the split application of potassium was not very helpful for most of the parameters studied including grain yield and half of the recommended dose of potassium (T_2) showed similar results to the recommended dose (T_1) and the other treatments except T_5. Thus it is recommended to apply potassium @ 20.5 kg ha^{-1} (T_2: 50% RDF, basal) at the final land preparation for the rice somaclone RSC2018-1.

Introduction

Rice is a staple food for large portions of the world's population and has a long cultural history. Asia is home to around 50% of the world's population, and the region consumes 90% of the world's rice production (Chauhan et al*.,* 2017; Dass and Chandra, 2013). In Bangladesh, the overall yield of rice is fairly low (34.6 million metric tons (FAO, 2022).

'Benapole' (also called *Benapole Rani*) is an indigenous popular coarse-grained aromatic rice cultivar, cultivated in some areas of Jashore district and the south Khulna region (Batiaghata and Dumuria Upazilas). The '*Benapole'* cultivar is popular due to its special aroma, lower production costs, and low inputs on intercultural operations. The main drawbacks, however, are the coarse grain, long life cycle, and low yield. A somaclonal variant (RSC2018-1) was isolated from *Benapole* rice through an *in vitro* technique using dehusked mature seeds in the Plant Breeding and Biotechnology Laboratory of Agrotechnology Discipline, Khulna University. The plant was characterized by small grain size, early maturity, and higher yield than the mother plant (Fuad, 2022).

Nitrogen (N), phosphorus (P), and potassium (K) are the three primary nutrients that a rice plant needs, with K

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being particularly crucial for growth and development (Doberman and Fairhurst, 2000). Potassium (K) the third essential plant nutrient after N and P, helps in improving grain quality, enhances water, and nutrient usage efficiency, stress tolerance, energy use efficiency, and the transfer of photosynthates and sugars from source to sink (Sharma and Singh, 2021). It also involves important physiological functions like osmoregulation, enzyme activation, regulation of transpiration by stomata, regulation of cellular cation-anion balance, and the transport of assimilates (Pavithira et al., 2017). In addition to its regular function, rice with optimal K nutrition has more spikelet panicle^{-1}, a higher percentage of whole grains, and a heavier 1000-grain weight. It also gives the rice plant strength and improves its resistance to strong winds by making the pseudo stems and stalks more rigid. To reduce lodging costs, this is essential. All of these collectively affect the caliber of crop production (Pavithira et al., 2017).

After nitrogen and phosphorus, potassium is the third most important nutrient for plants. Rice growth and yield characteristics were significantly influenced by split application of potassium compared to basal application. The enhanced growth and yield characteristics may ultimately be attributed to the application of 50% K_2O at the tillering and panicle initiation stages, which provided ample K and the ideal N-to-K ratio in the soil and plant, as well as efficient nutrient translocation (Surendran, 2005). Application of potassium in split doses increased the enzymatic activity and, most likely, increased nutrient mobilization in the soil and plants as well as the translocation of photosynthetic materials, ultimately leading to improved yields of grain and straw (Devasenapathy, 1997; Pal et al., 2000).

Nutrient management techniques influence crop production a lot; the selection of proper dosage and time of fertilizer application greatly influence overall yield in any crop (Flinn et al*.,* 1982; Flinn and DeDatta., 1984). Therefore, the goal of the current experiment was to determine the ideal timing and plan for applying potassium fertilizer to maximize the yield of rice somaclone, RSC2018-1.

Materials and Methods

The present experiment was conducted at Professor Dr. Purnendu Gain Field Laboratory, Agrotechnology Discipline, Khulna University, Khulna from September to December 2021. The soil in the experimental site was medium-high land. The soil properties of the study area were tested in the lab consisting of 16% sand, 36% silt, 51% clay, and 2.4% organic matter. The pH of the soil was 7.6.

Seeds of a somaclonal line RSC2018-1 were collected from the Plant Breeding and Biotechnology Laboratory, Agrotechnology Discipline, Khulna University, Khulna. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 7 treatments having 3 replications with each plot size 10 m².

Crop establishment and management

A piece of land 3 m × 2 m in size was selected for seed sowing by preparing it by plowing and cross-plowing 4 times with a power tiller followed by laddering. The seeds were pre-treated with Vitavax @ 2-3g kg^{-1} for 24 hours then presoaked in distilled water for 24 hours. Then the seeds were removed from the water and kept in the room condition for another 48 hours to allow germination. The germinated seeds were sown on the wet seedbed by broadcasting manually. The seed rate was 70 kg ha^{-1}. 25 days old seedlings were transplanted into the main field.

Recommended fertilizer dose (RDF) for HYV, *Aman* rice (life cycle less than approximately 120 days) is N: 70 kg ha^{-1}, P:10 kg ha^{-1}, K: 41 kg ha^{-1}, S:10 kg ha^{-1} (AIS, 2022). Full doses of P and S as well as half a dose of N, were used at the final land preparation. Another half-dose of N was administered in two equal splits, one at 15 DAT (Days after transplantation) and the other at 45 DAT. K was designated as the experimental treatment and was used as follows:

- T_1 - 100% RDK (RDK: Recommended dose of potassium) (K: 41 kg ha^{-1}) applied as basal (control)
- T_2 - 50% RDK (K: 20.5 kg ha^{-1}) applied as basal
- T_3 - 75% RDK (K: 30.75 kg ha^{-1}) applied as basal + 25% RDK (K: 10.25 kg ha^{-1}) applied at 45 DAT
- T_4 - 50% RDK (K: 20.5 kg ha^{-1}) applied as basal+50% RDK (K: 20.5 kg ha^{-1}) applied at 45 DAT
- T_5 - 25% RDK (K: 10.25 kg ha^{-1}) applied as basal + 75% RDK (K: 30.75 kg ha^{-1}) applied at 45 DAT
- T_6 - 25% RDK (K: 10.25 kg ha^{-1}) applied as basal +25% RDK (K: 10.25 kg ha^{-1}) applied at 15 DAT+ 25% RDK (K: 20.5 kg ha^{-1}) applied at 45 DAT
- T_7 - 50% basal (K 20.5 kg ha^{-1}) applied as basal) + 25% RDK (K 10.25 kg ha^{-1}) applied at 15 DAT +25% RDK (K 10.25 kg ha^{-1}) applied at 45 DAT

To maintain intercultural operations, weeding was done twice by hand, one at 15 DAT, and another at 40 DAT. No pesticides were applied in the field.

When 90% of the grains had turned a bright yellow color, the crops were harvested. Before harvesting, 5 plants from each plot were randomly uprooted to collect yield-contributing data. The following data were collected during the study period: plant height (cm), total tillers hill^{-1} (No.), effective tillers hill^{-1} (No.), leaf number, primary branches (No.), secondary branches (No.), flag leaf length (cm), panicle length (cm), total grain panicle^{-1} (No.), filled grains panicle^{-1} (No.), grain length (mm), grain width (mm), 1000 grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). The harvest index is expressed as the percent and calculated by the ratio of the economic yield and biological yield. Harvest Index (%) = (Grain yield/ Biological yield) × 100.

Grain yield and straw yield were all together regarded as biological yield. It is calculated with the following formula: Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Straw yield (t ha^{-1}). The grain yield was adjusted to 14% moisture content.

Statistical analysis

The collected data were analyzed for ANOVA and Tukey's HD test was used to compare treatment means in the computer using the statistical software 'Statistix 10'. Graphs were constructed with the help of the 'Microsoft Excel' program.

Results and discussion

Plant height

Figure 1. depicts the data on plant height. In all treatments, there were no significant variations in plant height. T_2 -50% RDK (K: 20.5 kg ha^{-1}) applied as a basal had the highest plant height (151.88 cm), as shown in Figure 1. T_5 had the shortest height (144.90 cm) with 25% RDK (K: 10.25 kg ha^{-1}) administered as basal + 75% RDK (K: 30.75 kg ha^{-1}) applied at 45 DAT. Our results are not in agreement with the findings of Bhiah et al. (2009), Mahbub et al. (2006), and William and Smith (2001). They stated that potassium higher dose and split application increased plant height. The inconsistency might be due to the use of different rice genotypes or due to different soil status.

No. of tillers plant^{-1} and No. of effective tillers plant^{-1}

The impact of potassium split dosages was found significant on the number of tillers plant^{-1} (Figure 2). The maximum number of tillers plant^{-1} (35.46) was obtained in T_4, where potash was applied in two splits (50% RDK, K: 20.5 kg ha^{-1}, applied as basal+50% RDK, K: 20.5 kg ha^{-1} applied at 45 DAT) which was statistically similar to T_1 (control), T_2 and T_6. The lowest value (21.66) was found with T_5. This result indicates that 50% K at as basal application and 50% at 45 DAT is more effective for increasing the number of tillers plant^{-1}.

The highest number of effective tiller plant^{-1} (32.2) was also observed with the treatment T_4 (Figure 3). These results were statistically similar to the control treatment (T_1) and T_6. The lowest value (17.8) was found with T_5. This might be explained by the fact that split dosages of K are more readily available than the single application as a basal dose. A higher level of K mobility to the plant from the soil is provided by the continual provision of K through split at critical stages of crop growth. According to Hu et al. (2004), more than half of the total K was accumulated during the phase from panicle start to flowering, which was crucial for rice's uptake of K. Similar results were reported by Ali et al. (2005), and Thakur (1993).

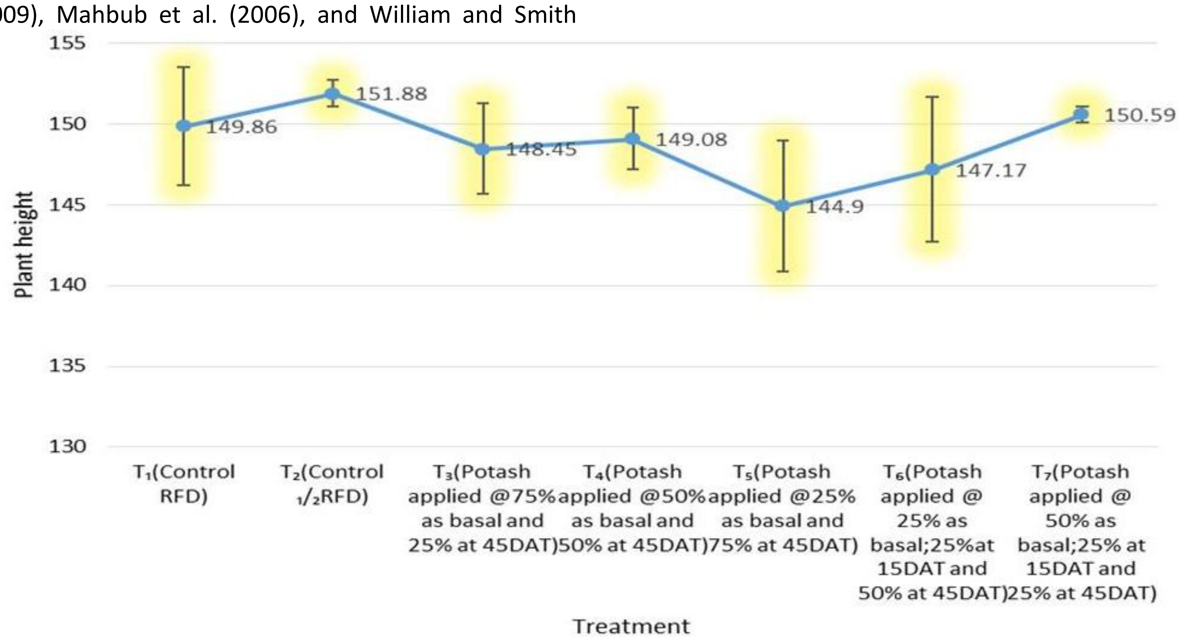

Figure 1. Plant height affected by split application of potash

Level of Significance: Non-significant

T_1 - 100% RDK ($K_{41\ kg/ha}$) applied as basal (control-1)

T_2 - 50% RDK ($K_{20.5\ kg/ha}$) applied as basal
T_3 - 75% RDK ($K_{30.75\ kg/ha}$) applied as basal + 25% RDK ($K_{10.25\ kg/ha}$) applied at 45 DAT
T_4- 50% RDK ($K_{20.5\ kg/ha}$) applied as basal+50% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT
T_5- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal + 75% RDK ($K_{30.75\ kg/ha}$) applied at 45 DAT
T_6- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal +25% RDK ($K_{10.25\ kg/ha}$) applied at 15 DAT+ 25% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

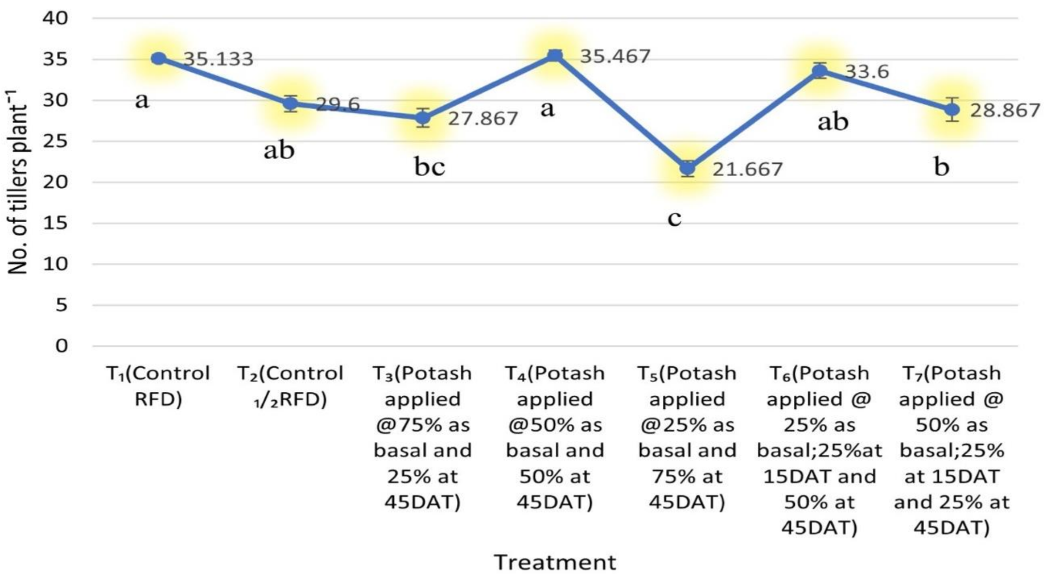

Figure 2. No. of tillers plant^{-1} affected by split application of potash
Level of Significance: *

Data followed by the same letter(s) are not significant statistically according to Tukey HSD (5%)
T_1 - 100% RDK ($K_{41\ kg/ha}$) applied as basal (control-1)
T_2 - 50% RDK ($K_{20.5\ kg/ha}$) applied as basal
T_3 - 75% RDK ($K_{30.75\ kg/ha}$) applied as basal + 25% RDK ($K_{10.25\ kg/ha}$) applied at 45 DAT
T_4- 50% RDK ($K_{20.5\ kg/ha}$) applied as basal+50% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT
T_5- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal + 75% RDK ($K_{30.75\ kg/ha}$) applied at 45 DAT
T_6- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal +25% RDK ($K_{10.25\ kg/ha}$) applied at 15 DAT+ 25% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

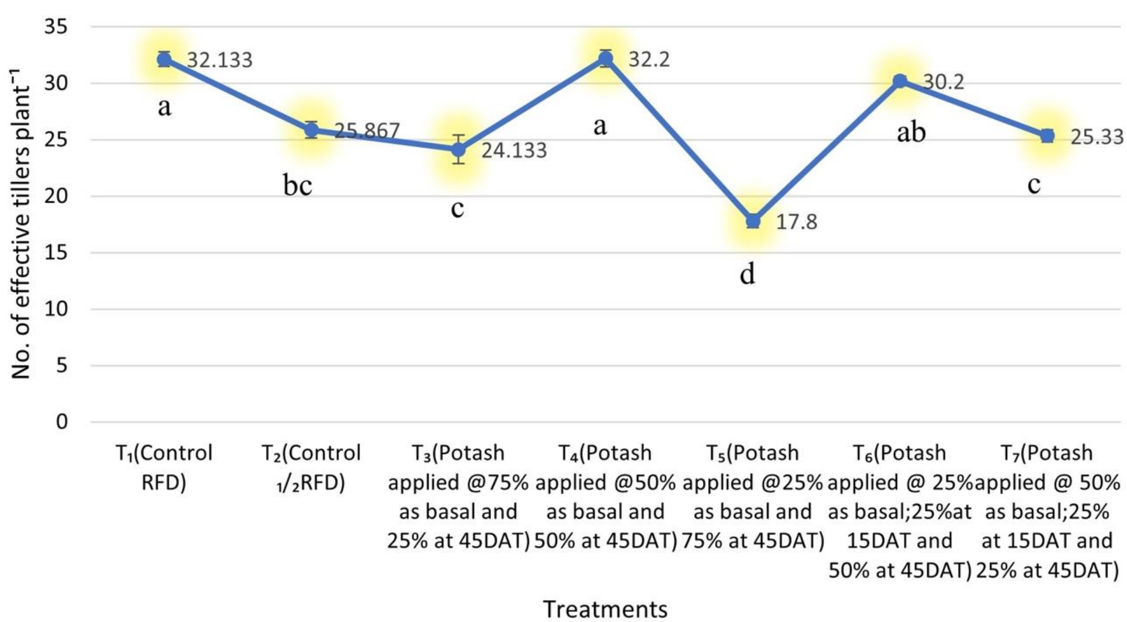

Figure 3. No. of effective tillers plant^{-1} affected by split application of potash
Level of Significance: *

Data followed by the same letter(s) are not significant statistically according to Tukey HSD (5%)
T_1 - 100% RDK ($K_{41\ kg/ha}$) applied as basal (control-1)
T_2 - 50% RDK ($K_{20.5\ kg/ha}$) applied as basal

T_3 - 75% RDK ($K_{30.75\ kg/ha}$) applied as basal + 25% RDK ($K_{10.25\ kg/ha}$) applied at 45 DAT
T_4- 50% RDK ($K_{20.5\ kg/ha}$) applied as basal+50% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT
T_5- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal + 75% RDK ($K_{30.75\ kg/ha}$) applied at 45 DAT
T_6- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal +25% RDK ($K_{10.25\ kg/ha}$) applied at 15 DAT+ 25% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

No. of primary and secondary branches

Primary and secondary branches were not found significantly different from the potassium treatments (Table 1). Primary and secondary branches in panicle are mainly genotypic dependent and less influenced by fertilizers (Voleti et al., 2013)

Table 1. Effect of split applications of K on growth parameters of rice (RSC2018-1)

Treatment	Length of Flag Leaf(cm)	No. of Leaves	No. Primary Branches	No. Secondary Branches	Panicle Length(cm)
T_1(RFD, control)	38.70 ab	106.47 a	8.66	19.06	25.05
T_2	40.69 a	90.67 bc	8.20	19.26	24.90
T_3	33.78 b	86.00 cd	8.26	17.80	24.96
T_4	36.50 ab	102.33 a	8.33	18.80	24.72
T_5	35.59 ab	77.40 d	8.13	18.13	24.50
T_6	39.52 ab	97.67 ab	8.46	16.80	24.42
T_7	35.34 ab	87.60 bcd	8.53	18.33	25.96
LS	*	*	NS	NS	NS
CV (%)	6.17	6.49	3.83	8.71	6.88

Data in a column followed by the same letter(s) are not significant statistically according to Tukey HSD (5%), NS- not significance.

Panicle length

The effect of various split doses of potassium for panicle length was not significant (Table 2). The highest panicle length was observed in T_7 (25.96 cm) where K was given in three splits- 50% as basal, 25% at 15 DAT, and 25% at 45 DAT. Manzoor et al. (2008) found that the increase in panicle length may be due to the continuous supply of K to the crop during crop growth stages.

Table 2. Effect of split applications of K on yield and yield contributing components of rice (RSC2018-1)

Treatment	No. of Unfilled Grains Panicle^{-1}	No. of Filled Grains Panicle^{-1}	Grain Length (mm)	Grain Width (mm)	Thousand Grain Weight (g)	Straw Yield (t ha^{-1})	Harvest Index (%)
T_1 (RFD, control)	6.51	113.91 a	6.77	2.66	20.74	9.99 a	28.66 ab
T_2	7.21	107.51 ab	6.78	2.78	20.58	8.45 abc	31.36 a
T_3	6.94	105.51 ab	6.84	2.72	20.77	8.34 bc	29.47 ab
T_4	5.66	110.53 ab	6.81	2.69	21.02	9.49 ab	30.00 ab
T_5	7.07	103.53 ab	6.82	2.66	20.54	7.15 c	30.25 b
T_6	5.39	105.12 ab	6.86	2.71	20.60	9.26 ab	27.20 c
T_7	5.55	99.38 b	6.80	2.71	21.10	7.46 c	31.45 a
LS	NS	*	NS	NS	NS	*	*
CV (%)	25.80	4.24	1.32	2.87	3.32	6.43	4.65

Data in a column followed by the same letter(s) are not significant statistically according to Tukey HSD (5%), NS- not significance.

Spikelet panicle^{-1}

Figure 4 demonstrates the effect of potassium treatments on spikelet's panicle^{-1}. Data on this parameter was variable (104.93 to 120.22) and the variations were found statistically insignificant, however, the maximum number of spikelet panicle^{-1} (120.22) was obtained from the control treatment (T_1) when whole potash was applied as a basal dose. Grain yield increases in most rice cultivars with an increased number of spikelet panicle^{-1} (Nwe et al., 2015). According to Yoshida (1981), spikelet panicle^{-1} was the most important component limiting yield in rice. Increased potash uptake efficiency may be the reason for the rise in the number of grains panicle^{-1} when K was administered during the maximum tillering and panicle initiation stages (Manzoor et al., 2008).

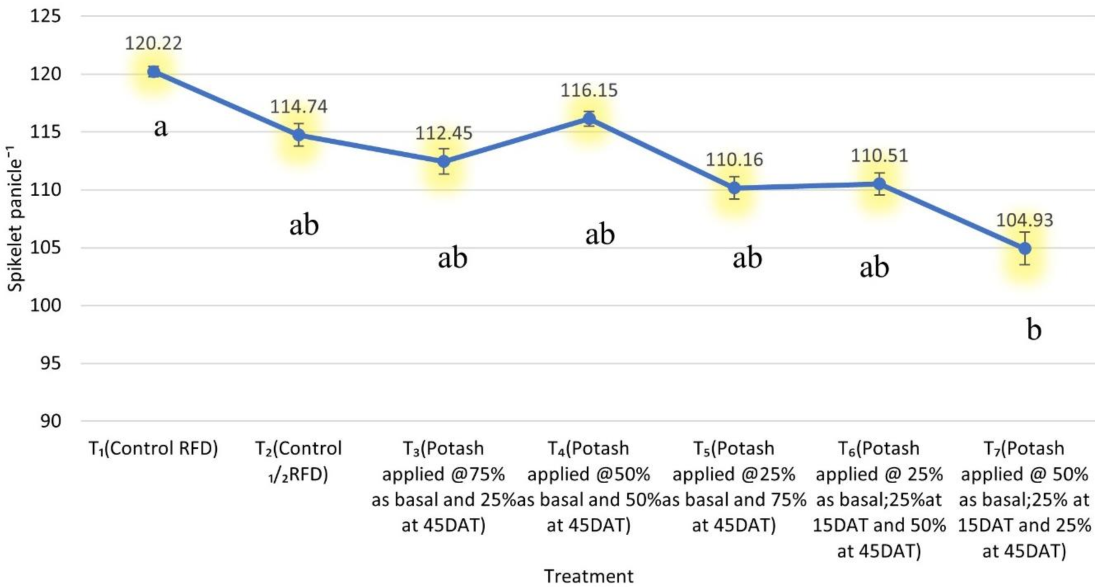

Figure 4. Spikelet panicle^{-1} affected by split application of potash

Level of Significance: *

Data followed by the same letter(s) are not significant statistically according to Tukey HSD (5%)

T_1 - 100% RDK ($K_{41\ kg/ha}$) applied as basal (control-1)

T_2 - 50% RDK ($K_{20.5\ kg/ha}$) applied as basal

T_3 - 75% RDK ($K_{30.75\ kg/ha}$) applied as basal + 25% RDK ($K_{10.25\ kg/ha}$) applied at 45 DAT

T_4- 50% RDK ($K_{20.5\ kg/ha}$) applied as basal+50% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

T_5- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal + 75% RDK ($K_{30.75\ kg/ha}$) applied at 45 DAT

T_6- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal +25% RDK ($K_{10.25\ kg/ha}$) applied at 15 DAT+ 25% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT)

Filled grain panicle^{-1}

The filled grains panicle^{-1} varied from 99.38 (T_7) to 113.91 (T_1). Among all the treatments studied only T_7 produced significantly lower grains panicle^{-1} but the other treatment combinations were same for this parameter. This result indicates that the control treatment (100% K applied as basal) or the treatment T_2 (50% RDK as basal) is more easy and cost-effective for the rice cultivar under study. This result is in agreement with Kabir et al. (2004), who recommended that potash should be applied at the final land preparation for local rice landraces, however, Ramos et al. (1999) reported that split application of K at active growth stages led to an adequate potash supply that increased plant photosynthesis rate and ultimately increased grain yield.

Thousand grain weight

The 1000-grain weight of rice somaclone RSC2018-1 was not significantly influenced by the split application of potassium fertilizer (Table 2). However, numerically the highest 1000-grain weight (21.1 g) was observed in T_7 where K was applied in three equal splits. The findings of Manzoor et al. (2008) support this observation.

Grain yield

The results of the potassium fertilizer treatments on the grain yield of rice somaclone RSC2018-1 are demonstrated in Figure 5. The grain yield was significantly influenced by the treatments at a 5% level of significance. The highest yield (4.06 t ha^{-1}) was recorded at T_4 and it was significantly higher than T_5 (3.1 t ha^{-1}) but was statistically similar to other treatments. So, it can be said that split applications of potash have not much influenced on grain yield for the rice somaclone under study. Local rice cultivars require half doses of chemical fertilizers for their growth and yield (Parvin et al., 2006, and Ghose. 2003). This report is in agreement with the findings of the present investigation. It was noticed that rice yield in the T_2 treatment (50% RDK as basal) produced a grain yield similar to the control treatment as well as to most split applications of potash.

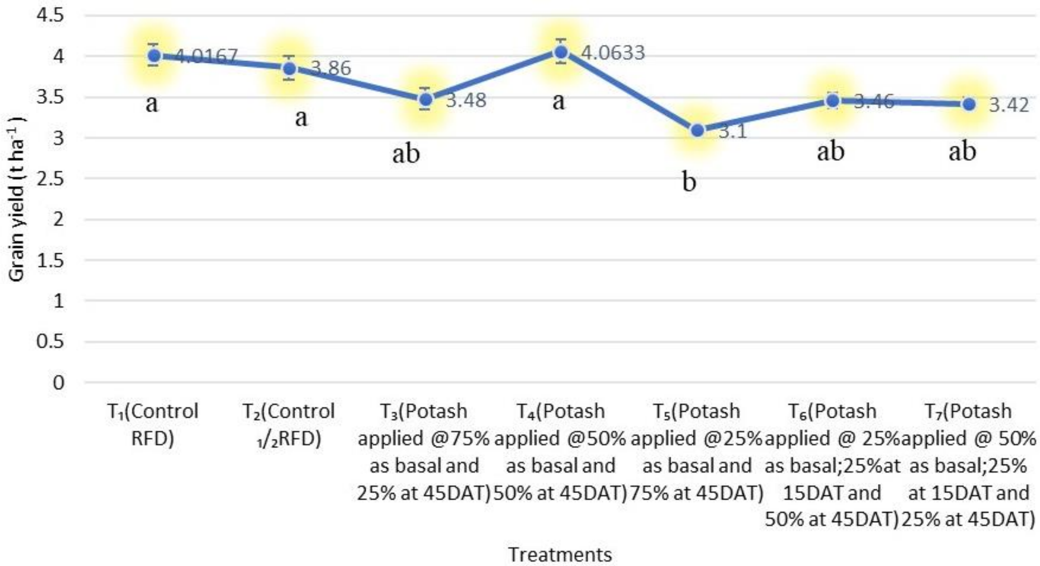

Figure 5. Grain yield (t ha^{-1}) affected by split application of potash

Level of Significance: *

Data followed by the same letter(s) are not significant statistically according to Tukey HSD (5%)

T_1 - 100% RDK ($K_{41\ kg/ha}$) applied as basal (control-1)

T_2 - 50% RDK ($K_{20.5\ kg/ha}$) applied as basal

T_3 - 75% RDK ($K_{30.75\ kg/ha}$) applied as basal + 25% RDK ($K_{10.25\ kg/ha}$) applied at 45 DAT

T_4- 50% RDK ($K_{20.5\ kg/ha}$) applied as basal+50% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

T_5- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal + 75% RDK ($K_{30.75\ kg/ha}$) applied at 45 DAT

T_6- 25% RDK ($K_{10.25\ kg/ha}$) applied as basal +25% RDK ($K_{10.25\ kg/ha}$) applied at 15 DAT+ 25% RDK ($K_{20.5\ kg/ha}$) applied at 45 DAT

Straw yield

Data on straw yield are presented in Table 2 which indicated that some K treatments T_5 and T_7 produced significantly lower straw yield but in other treatments straw yield was statistically similar. Thus T_2 treatment might be regarded as suitable for straw yield as it is cost-effective.

Harvest Index

The variation of the harvest index of rice due to different split applications of fertilizer is described in Table 2. The harvest index as affected by the split application of potassium was significantly different at the 5% level. The maximum harvest index was procured by T_2 (50% RDK as basal), and the lowest was by T_6 (25% as basal, 25% at 15 DAT, and 50% at 45 DAT). Though the application of T_2 (50% RDK as basal) reduces the cost (labor and production costs), farmers can benefit from the application of T_2 (50% RDK as basal).

Conclusion

The present investigation revealed that the studied rice somaclone RSC2018-1 produced a satisfactory yield without split application of potassium and if the dose is considered, 50% of the recommended dose of potash is sufficient enough as a basal single application to produce desirable yield. The experiment might be repeated in other locations for more strong confirmation.

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